RCN: OceanObsNetwork

Annual Report for 2016

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Table of Contents — Page No.

1. Overview.

The goal of the RCN OceanObsNetwork [RCN] is to foster a broad, multi-disciplinary dialogue, enabling more effective use of ocean observing systems, consistent with national and international efforts, to inform societal decisions.

To achieve this goal, the RCN has defined a series of objectives:

- Motivate commitments to sustaining ocean and marine observing systems
- Stimulate inter-disciplinary cooperation for both observations and analyses
- Facilitate open exchange of ocean data
- Promote interoperability
- Improve the flow of critical ocean observation information to key stakeholders
- Stimulate capacity building and retention in ocean and marine observations community

The RCN also considers related issues such as the evolution of biological observations with eDNA and discipline related subjects where important developments are occurring. The network members may propose additional subjects.

See Appendix I for the complete RCN Terms of Reference.

The RCN consists of senior ocean scientists from the US and other countries from diverse ocean science disciplines. The RCN members and volunteers are listed in Appendix II.

Information on the December 2015 annual meeting is provided in the Appendix III.

The following paragraphs highlight the RCN activities for 2015/16.

2. Working Environment.

The RCN operates primarily through electronic information exchange. Its members use websites, discussion fora and other tools for communication and collaboration.

The RCN met two times this year, one virtual meeting and an annual in-person meeting. In 2016, the virtual meeting was held on July 11. The face-to-face meeting was held in San Francisco on December 13 2015, prior to the start of the AGU meeting.

The RCN Plenary reviews and comments on Working Group (WG) reports prior to their public release and forwarding to appropriate parties. Coordination of the RCN activities with existing networks is facilitated by RCN members whose organizations are participating in those networks.

3. Working Groups.

The RCN is primarily a forum to address issues of enhancing ocean observation and information and the challenges of multi-disciplinary research across the ocean sciences. It is not a body chartered to undertake new scientific research. Issues engaged by the RCN are addressed by the body as a whole (Plenary) or through working groups constituted by the RCN. A working group generally focuses on one of the RCN objectives and produces a report clearly identifying the issues, approaches, impacts and recommendations for achieving the objective(s).

Members of the RCN and other invited experts constitute working groups. Network members may serve on multiple working groups. In their deliberations, the working groups may invite external experts to make presentations and provide background on issues being addressed.

Four working groups were active or in initiation phase in 2015/2016.

A. The Outreach and Education Working Group

The working group was started mid-August of 2012 and continues the webinars series, "the Blue Marvel - Ocean Mysteries". The webinars are available for viewing and access through the IEEE OES website. The webinar presentations – dates and speakers - are summarized in the events list of Section 7 of this report.

B. Support for BIO- TT

Last year, the RCN worked with the Interagency Ocean Observation Committee's (IOOC) Biological Integration and Observation (BIO) Task Team in organizing a workshop with the goal to identify and prioritize additional crosscutting biological and ecosystem observational needs (beyond the existing 6 IOOS biological core variables). The workshop was held in November 2014 and the final report and recommendations were formalized in 2015 and submitted to the US government for release clearance. The report is being released in Dec 2016 with recommendations to: 1. improve the availability of observations on the currently identified IOOS core biological variables: phytoplankton species; phytoplankton abundance; zooplankton species; zooplankton abundance; fish species; and fish abundance; and 2. identify, and prioritize additional cross-cutting federal agency biological and ecosystem observation needs.

C. Citizen Science Working Group

A working group was initiated in November 2014 to look at existing citizen science activities and areas for which further emphasis can be placed. Presentations were given at the 2014/5 RCN meetings. Further work is to be defined by the working group leads. The issue being addressed is the value of citizen science for ocean research.

D. "Promoting Implementation of Multi-Disciplinary Sustained Ocean Observations" (IMSOO)

A working group has focused on the organization of a workshop "Promoting Implementation of Multi-Disciplinary Sustained Ocean Observations" (IMSOO) which will take place February 8-10, 2017. The focus is the definition and plans for three thematic demonstrations that can draw together multidisciplinary contributions to a demonstration/research topic. The three topics planned are boundary currents, oxygen minimum zones and phytoplankton. Planning for the workshop has been ongoing for all of 2016.

4. Outreach and Dissemination.

In addition to the webinars mentioned above, RCN members participated in national and international meetings such as the IEEE/MTS Oceans 2016 in Monterey CA, the AGU and EGU, and the EGU Ocean Sciences Conference. They also interfaced with project activities focused on interoperability such as the NeXOS, Atlantos and Ocean Data Interoperability Platform (ODIP II) programs. Presentations were given, and papers released as part of the proceedings.

5. Web Outreach.

The following websites provide information regarding RCN activities:

- Oceanmysteries.net (webinar advertising and registration).
- Oceanrcn.org
- https://sites.google.com/site/oceanobservingrcn/ (CSIRO)

6. Events and activities.

Date	Activity	Reference
Oct 22 2015	Webinar	Dr. del Rio – From Sensors to Users
Nov 9-13	GEO Summit	Discussions with GOOS and Blue Planet on RCN collaboration
Dec 2	Webinar	Mr. Delauney- New approaches for biofouling protection
Dec 13	RCN Meeting	Face-Face annual meeting
Jan 20 2016	Citizen Science WG	Planning for February meeting
February 22-26	AGU Ocean Sciences	CS WG Meeting; IMSOO planning meeting of organizing committee, GOOS and sponsors; citizen science working group meeting; ocean biology poster
March 14	Oceanology International	Ocean sensors for chemistry and biology developments and innovations
April 18-19	EGU	Presentation on Ocean Biology sensors
April 27	IMSOO WG	IMSOO Workshop planning
May 3-5	ODIP meeting	Data Interoperability and best practices discussions
June 1	GEO workshop	Session on Ocean observations
July 11	RCN virtual meeting	
July 28	Webinar Series	Dr. Zielinski – optical sensors
Oct 19	Oceans2016 Conference	Sensor interoperability session, discussion on data quality
December 11	Planned RCN Meeting	In person meeting at San Francisco

7. Acknowledgement
The RCN:OceanObs is a five-year National Science Foundation (NSF) funded project. The RCN would like to thank NSF for their support under Grant OCE 1143683.
Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Appendix I – RCN Terms of Reference.

Background

The oceans provide many important functions within the Earth system including strong coupling with weather and climate dynamics, providing food and energy resources, supporting trade and commerce, offering extensive stabilization for variations in our environment and being a resource for biodiversity. The need for improved coordination in ocean observations is more urgent now given the issues of climate change, sustainable food sources and increased need for energy. Ocean researchers must work across disciplines to provide policy makers with clear and understandable assessments of the state of the ocean.

New technologies and approaches are emerging to vastly improve ocean observations. Cabled observatories are an example of a paradigm shift, providing a relative abundance of power and bandwidth for observations covering scales from cm to km and times from seconds to decades. Sensors traditionally only available in laboratories can now be adapted for in-situ observations. The potential for interdisciplinary collaboration is significant. The Oceans RCN is a forum to address these issues and develop recommendations on key topics of ocean observation and information.

Goal

The goal of the RCN is to foster a broad, multi-disciplinary dialogue, enabling more effective use of ocean observing systems, consistent with national and international efforts, to inform societal decisions.

Objectives

To achieve this goal, the RCN has defined a series of objectives:

- Motivate commitments to sustaining ocean and marine observing systems
- Stimulate inter-disciplinary cooperation for both observations and analyses
- Facilitate open exchange of ocean data
- Promote interoperability
- Improve the flow of critical ocean observation information to key stakeholders
- Stimulate capacity building and retention in ocean and marine observations community

The RCN will also consider related issues such as integration of space-based and in-situ measurements, and innovative concepts in sensors, information systems and user interfaces. Additional subjects may be proposed by the network members.

In achieving these objectives, the RCN will motivate new research outcomes, provide wider visibility for the value and impacts of ocean observations and encourage a new generation of scientists to focus on the oceans and their challenges.

Operations and Working Methods

The RCN is primarily a forum to address issues of enhancing ocean observation and information. It is not a body chartered to undertake new scientific research. Issues engaged by the RCN will be addressed by the body as a whole (Plenary) or through working groups (WG) constituted by the

RCN. A working group will generally focus on one of the objectives cited above and will produce a report clearly identifying the issues, approaches, impacts and recommendations for achieving the objective(s).

Working groups will have a defined term of operation, generally six months (renewable), to assess issues and then submit their recommendations for review by the Plenary. The reviewed recommendations will be provided to international, national and program level organizations for consideration and possible implementations. Working Groups will be constituted by members of the network and other invited experts. They will create Terms of Reference including objectives, a schedule, an operations modality and a list of deliverables. Network members may serve on multiple working groups. In their deliberations, the working groups may invite external experts to make presentations and provide background on issues being addressed.

The RCN working environment will be as follows:

1. The RCN will operate primarily through electronic information exchange. The RCN will have websites, discussion forum and other tools for communication and collaboration.
2. The RCN will meet three times per year, two virtual meetings and an annual in-person meeting.
3. The RCN Plenary will review and comment on the WG reports prior to their forwarding to appropriate parties.
4. The RCN will work closely with existing coordination bodies and mechanisms for ocean and marine observations. Coordination with existing networks will be facilitated by members of the Steering Committee and senior network members whose organizations are participating in existing networks such as those under UNESCO IOC and GEO.

Outputs

The RCN will develop and deliver reports covering subjects that support achieving the objectives above. The reports will identify issues, approaches and recommendations for achieving the objectives.

Participation

The RCN will be a long-term international forum on observatories, data, modeling and information for scientists and users of ocean information. Broad participation of physical, biological, and biogeochemical oceanographers in the RCN is essential. Inclusion of nonscientist end users and decision makers in the RCN is strongly encouraged. A list of current participants is maintained by the project office. Additional network membership may include scientists from current observing systems and also data and information users from government, industry and education and research institutions. These will initially be solicited though contacts by the Steering Committee and the senior network members.

Appendix II – OceanObsNetwork Members and Participants.

First Name	Last Name	Organization	E-mail address
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Appendix III - Minutes of December 13 2015 RCN Meetings

The fourth annual face-to-face meeting of the OceanObs research coordination network (RCN) took place on Sunday December 13, 2015 at the Marriott Marquis, in San Francisco, the day before the start of the American Geophysical Union (AGU). The list of attendees is provided at the end of this document.

1. Agenda

The agenda is summarized below:

8:30	Coffee and Registration
9:00	**Welcome and Introductions** Jay Pearlman, IEEE Sandy Williams, IEEE
9:15	**Foundations** – visions and direction Victor Zykov, Schmidt Foundation Sara Bender, Moore Foundation
9:50	**Sustainability** – perspectives of industry and GEO Paul Holthus, World Ocean Council (WOC) Hans-Peter Plag, Old Dominion University
10:20	Break
10:40	**XPRIZE Activities** –innovation session at Oceans and the challenges ahead Jyotika Virmani, XPRIZE Foundation
11:15	**Data Systems:** US – OOI, Oscar Schofield, Rutgers University European –SeaDataNet, Dick Schaap ODIP – Helen Glaves, British Geological Survey (BGS) Ocean Network Canada (ONC), Benoit Pirenne
12:15	Lunch
13:30	**<u>Panel on Ocean Biology – from Microbes to Whales</u>** Environmental ‘omics (ECOGEO), Chris Scholin, MBARI for Elisha-Wood-Charlson, University of Hawaii Microbial needs and methods, Chris Scholin, MBARI Plankton needs and methods, Heidi Sosik, WHOI Marine Biodiversity Observation Networks, Francisco Chavez, MBARI AtlantOS shared infrastructure for biodiversity, Eric Delory, PLOCAN GOOS and IOOS Biology BIO-TT panel, Samantha Simmons, Marine Mammal Commission (MMC) IOOS Biology Sensor Working Group report Physics/Biogeochem/Biology/Ecosystems/Biodiversity Essential Ocean Variables - Group discussion
15:55	**Break**
16:15	**ENVRI+,** Ari Asmi, University of Helsinki
16:45	**Does Citizen Science support research?** – Mairi Best, Consultant
17:15	**Concluding Remarks** Jay Pearlman, IEEE Sandy Williams, IEEE
17:30	Adjourn

2. Welcome and Introductions

Jay Pearlman opened the meeting by reminding the audience of the RCN motivation: *Foster a broad, multi-disciplinary dialogue, enabling more effective and sustained use of ocean observing systems for addressing local, national and global challenges.* He then summarized the status of the various working groups. The following groups have been completed, and the outcomes documented:

- Open Data
- In-situ-RS Interfaces
- Biology core variables (support BIO-TT).

The working groups below are still on going:

- Ocean biology sensors
- Citizen observations
- Essential Ocean Variables

In addition, the RCN may participate in the 2017 GEO Blue Planet Symposium. Following this brief overview, the meeting participants introduced themselves. Jay then reviewed the challenges identified the previous year (see summary by Heidi Sosik), and highlighted the objectives for the meeting:

- Foster panel and participant dialogue
- Identify key issues and recommendations – Panel Chair should document these recommendations
- Identify activities for 2016.

3. Foundations: Visions and Directions

3.1. Opportunities for Advancement in Ocean Observations: Visions and Directions; Victor Zykov, Schmidt Ocean institute

The Schmidt Ocean Institute (SOI) was founded by Eric and Wendy Schmidt to accelerate the pace of understanding the ocean. For that purpose, the foundation focuses on technological innovation, intelligent observation and analysis, and open sharing of

information. They combine advanced science with state-of-the-art technology to achieve lasting results in ocean research, catalyze open sharing of the information, and to communicate this knowledge to audiences around the world.
Structured as a facility operator, SOI provides scientists with access to a research vessel, best technologies and technical support in exchange for open sharing of information and data. The program officers have five focus areas:

- Commitment to Excellence in Oceanographic Research Operations
- Infrastructure, Platform, and Technology Development for Marine Sciences
- Collaborative Scientific Research aboard Falkor
- Communications, Education, and Outreach Program
- Open Sharing of Information, Data, and Research Outcomes.

Ocean sciences are in a large-scale transition from ship-based to robot-based observation and research. The role of research ships is shifting from direct sample collection to operational and R&D support. One can think of ships as platforms for robot maintenance, data storage, QA/QC, real-time integration of data and support for interpretation and visualization with the goal of helping science research to become more efficient. We expect, for example, that ships will support more and more real-time data integration and interpretation. Victor demonstrated coordinated robotics as an illustration. A web site for robot monitoring kept track of glider assets in near real-time. He demonstrated imagery used to observe daily change (sea floor modeling). A ship can act as a high performance computer at sea for numeric modeling and analysis. Victor gave several examples: tracking hidden tides in Tasmania and modeling of tidal dynamics at Scott reef in the Timor Sea. Scientific data interpretation and analysis interfaces are becoming more visual: human perceptive system is 85% vision-based - it's the highest bandwidth human data processing system; broadband connectivity from ships is mostly used for video – raw, un-interpreted, high bandwidth data. During a robotics cruise, an AUV collects images; a subset is sent to an interface for students to log in and do citizen science (using Squiggle); 22000 tags are transported back to ship and used to train classifiers.

3.2. Sara Bender, Gordon and Betty Moore Foundation

Sara Bender did her graduate work at the University of Washington and has a degree in biological oceanography. She is a program officer for the marine microbiology initiative at the Gordon and Betty Moore Foundation. The Moores define characteristics of the foundation such as "innovative, intellectually rigorous, take risks, operate efficiently, exercise humility, and remain focused on measurable results".
In addition to the Marine Microbiology initiative, Sara gave a list of other activities including patient care, environment and San Francisco Bay area programs (primarily conservation and learning). The foundation approach has identified four filters: potential to make a difference and achieve an enduring impact; importance to the foundation; measurable outcomes; and contribution to a portfolio effect. To implement strategic philanthropy, the foundation engages in dialogues with non-profit organizations and seeks alignment around goals and paths forward of mutual interests
For the Marine Microbiology initiative, Sara identified the strategy as: breaking barriers for science, (see chart - strategies), promoting the development of experimental model systems, and developing technology, models, methods and theory for science focus areas. The initiative is funded until 2019. The approach includes: investigator awards, multidisciplinary teams, enabling

technology and structures; and community–infrastructure projects. By 2019, the goal is to achieve a paradigm shift by uncovering the principles that govern how microbes interact with each other. Examples in the area of Technology and Methods development include: float cytoBOT (WHOI); environment sample processor (MBARI); seafloor incubator (MBL); and the Zooglider (SIO). Sara also gave examples of field projects, and talked about their experimental model portfolio. This activity is focused on genetic tool development; 35 grants have just started with the goal of genetics becoming a part of the ocean toolkit.

3.3. Questions for the Schmidt Ocean Institute and the Moore Foundation:

Eric Delory – In Europe they are interested in what happens at the junction between land and ocean.

> Victor Zykov – SOI has yearly meetings to address these issues; they have a very open approach for collaboration and receive proposals from the international community.
>
> Sara Bender- they have grantees in Europe and all over the world – typically Moore Foundation does not have open calls.

Cindy Chandler –where does the data end up and where do the tools generated by research end up?

> Sara Bender– there is a data sharing plan for grantees but there is no unique location for tools; they use github and other repositories.
>
> Victor – the Institute and the grantees participate in the ownership of data; for imaging data they need methods that are more automated, possibly relying on artificial intelligence; OPEN AI is a recent announcement. With a few exceptions they are woefully behind in archiving these data.

Helen Glaves commented that there is an opportunity for a data working group in the OceanObs RCN that can look at alternative state of the art solutions.

4. Sustainability – Perspectives of Industry and GEO

4.1. Hans-Peter Plag, Old Dominion University; The GEO blue planet initiative – understanding the role of the ocean in the earth life support system

Hans-Peter Plag defined sustainable development as a development that meets the need of the present while safeguarding the earth life support systems. He showed economy as the link between society, and the earth support system. Linking science and earth observation to sustainability means linking science and earth observation to economy and its impact of the earth life support system. Hans-Peter identified the current sustainability challenge as the competition between energy and food production in term of natural resources. He compared the impact of major volcanic eruptions (Tambora and Toba), and major earthquakes, to the current impact of humanity on the earth system. He also briefly addressed the potential impact of climate change. For "Blue Planet", the theme is Ocean and society. Blue Planet builds on existing programs and coordinating mechanisms, addressing ocean observations and their societal applications. Blue Planet adds value by:

– Providing additional exposure and visibility to these programs
– Identifying synergies between programs, both within Blue Planet and with related activities across the GEO community and beyond
– Linking data to products and information to increase knowledge
– Demonstrating societal benefits
– Where possible, making a concerted effort to link to relevant policies

and policy frameworks.

In the post-GEO 2015 work program, the Blue Planet Initiative can become a GEO flagship with the following vision: an informed society that recognizes the oceans' crucial role in Earth's life-support system and is committed to stewardship of the oceans for a healthy, safe and prosperous future for all. The mission is defined as " to advance and exploit synergies among the many observational programs devoted to ocean, coastal and inland waters; to improve engagement with a variety of users for enhancing the timeliness, quality and range of services delivered; and to raise awareness of the societal benefits of ocean observations at the public and policy levels". The 3rd Blue Planet Symposium, a forum for addressing these subjects, is tentatively scheduled for spring 2017. It will address the role of the ocean in the earth life support system.

4.2. Paul Holthus, CEO World Ocean Council, Ocean industry leadership and collaboration in ocean observations

Paul Holthus leads the World Ocean Council (WOC), the international multi-industry business leadership alliance on ocean sustainable development, science and stewardship. The Third WOC sustainable summit was held in Singapore in 2015. New risks for ocean industries are associated with converging marine environment and sustainability trends, as the use of the ocean expands in the kinds, levels, duration and location of ocean economic activity.

The WOC is:

- Bringing ocean industries together, e.g. shipping, oil/gas, fisheries, aquaculture, tourism, offshore renewables, etc.
- Catalyzing private sector leadership and collaboration in
- Advancing "Corporate Ocean Responsibility"
- Communicating responsible ocean economic activity.

The WOC has over 85 members worldwide, and over 35,000 in a global network. Its goal is to foster a healthy, productive global ocean and its sustainable use and stewardship by responsible ocean business community. The objective is to create business value for responsible companies:

- Access and social license for responsible ocean use
- Synergies and economies of scale in addressing issues
- Stability and predictability in ocean operations.

The WOC has six priority program areas:

- Ocean Policy and Governance: for developments important to ocean industries, e.g. Convention on Biological Diversity (CBD); Law of the Sea
- Marine Spatial Planning (MSP): in areas where it is developing rapidly, e.g. US; EU; Australia
- Operational Environmental Issues: Marine Invasive Species – ballast water, hull biofouling; Sound and Marine Life; Marine Mammal / Vessel Interactions; Port Waste Reception Facilities / Marine Debris; Water Pollution/Waste Discharge
- Regional Ocean Business Council: Arctic; SE/E Asia, Med, E Africa/W Indian Ocean;

Caribbean

- Smart Ocean / Smart Industries: observations and data from ships/platforms of opportunity
- Sea Level Rise: Port/coastal infrastructure resiliency and adaptation.

Paul addressed the Smart Ocean / Smart Industries program in more detail, describing the WOC efforts to expand, improve and accelerate the use of commercial ships and platforms of opportunity to collect ocean, weather and climate data. The WOC is developing pilot projects on data collection by industry, e.g. in the Arctic.

5. Jyotika Virmani, senior director, energy and environment, XPRIZE Foundation
XPRIZE inspires the belief that we can create a better future. The prizes drive radical breakthroughs that benefit humanity. The XPRIZE foundation drives innovation by designing and managing high-profile global competitions that tackle the Grand Challenges of our time. Prizes target grand challenges and market failures. They engage innovators worldwide, and partner with top global brands The goal is to ***make the impossible possible.*** Historically, it started with the Orteig prize which kick-started civil aviation with Lindberg's flight across the Atlantic. In 1996 XPRIZE opened up space travel to private industry with the Ansari XPRIZE. The current portfolio includes $82 Million of active XPRIZEs.
Jyotika detailed the Wendy Schmidt Ocean Health XPRIZE for innovations in pH sensors. There were two Prize Purses of $1M for Accuracy & $1M for affordability. This was recently awarded. The intended breakthroughs were: to inspire innovations in ocean sensing technology; catalyze ocean acidification research; catalyze the ocean services industry; and inspire the public to engage. The prize was launched in 2013, and awarded in July 2015. Sixteen teams participated in the lab trials at MBARI; 14 teams competed in the coastal trials at the Seattle Aquarium; and 5 teams remained for the deep-sea trials in Honolulu (where Entries were tested down to 3000 meters depth, which took 5 to 6 hours). The winner was Sunburst sensors, who won both prizes (a team from Montana with 9 people in the company); the 2nd place for Accuracy was team Durafet; the 2nd place for the Affordability prize was won by ANB sensors (UK). Other innovations included a hybrid sensor from Japan, an Optode from Austria (excellent ease of use), and a device for the surfing community using a smart phone.
Post prize activities included a workshop on **"**Catalyzing Ocean Services in a World of Abundant Ocean Data**"** at the MTS/ IEEE Ocean conference in October 2015 in Washington DC. Teams competed as start-ups and pitched their best vision for the future of ocean big data services. The Workshop Winning Teams included "Blue Button" - making relevant data available in one location for opportunistic companies to develop useful products; and "Ocean Channel" - addressing how oceans impact you personally, delivering specialized products for local users.
As part of the XPRIZE Ocean Initiative (healthy, valued and understood oceans), Shell's Ocean Discovery XPRIZE will be launched tomorrow. Team registration will end on the 30th of June 2016, with an award at the end of 2018.

6. Data Systems

6.1. Oscar Schofield, Rutgers University, the Ocean Observatories Initiative

The Ocean Observatories Initiative (OOI) is composed of 7 array groups covering 61 sites (moorings, profilers and nodes), 34 mobile assets (gliders and AUVs), 930 planned instruments, and 2848 potential data product streams. The arrays consist of the OOI cabled array/endurance array (Washington and Oregon coastal lines), the pioneer array, and the global arrays (global station Papa and global Irminger sea station).

The cyberinfrastructure includes east and west coast systems backing each other. Data from the systems is asynchronous. Assets are in the water now (there are 2 years of data in some sites). The new OOI website goes live tomorrow (December 14). It supports drilling down to specific sensors for each array. The data portal is the primary source of data sets and metadata. Upcoming data tools for 2016 include ERDAP and raw data files. Data can be accessed via the Internet. The help desk can handle questions about data, data access, and instrumentation. An ocean education portal provides mapping and visualization tools and includes a resource database.

6.2. Dick Schaap, SeaDataNet, Pan-European infrastructure for marine and ocean data management and EMODNET

SeaDataNet has set up and operates a pan-European infrastructure for managing marine and ocean data by connecting National Oceanographic Data Centres (NODCs) and oceanographic data focal points from 35 countries bordering European seas. SeaDataNet is based on a set of common standards for metadata and data formats for the marine domain, adapting ISO and OGC standards and achieving INSPIRE compliance. It includes controlled vocabularies for the marine domain with greater than 160,000 terms over more than 60 lists). A set of tools is provided for use by each data centre – capacity building and standardization. Pan-European services provide an overview of organizations in Europe with their involvement in marine projects, data sets, cruises and monitoring. The services support discovery, access, visualization and data products. There is a common discovery and access portal but the data is downloaded from individual centers which archive or process the data (102 data centers).

SeaDataNet is a core partner in developing and building the European Marine Observation and Data Network (EMODNet). Dick gave the example of the EMODNet Chemistry project, which has a scope of numerous chemical substances. Three search interfaces for human users, upgraded as part of the project: Quick Search with dynamic drilling down of search results; Extended Search with more flexibility for combining search options, including free search; and search with an interactive Matrix of variables in specific marine regions. In addition to the human interfaces, a harvesting tool is available (machine interface). This tool is used to create and maintain buffers of data sets following a specific profile. The data buffers are then regularly provided to regional experts for harmonisation and validation of the regional data collections using the versatile ODV software. These validated aggregated data collections form the basis for the creation of regional data products such as interpolated maps per parameter in time which are published as OGC services, including full metadata references to the used data sets. Also visualisations of time series and profiles in time at selected locations are provided on-the-fly by OGC WPS services. The EMODNet Bathymetry project and portal brings together bathymetric surveys of European seas and produces, publishes and serves a harmonized and medium resolution Digital Terrain Model (DTM) of all European seas. This DTM has a 16 times higher resolution as the GEBCO product and for each grid cell full metadata is included to the used data set. The DTM is freely downloadable in a range of data formats.

6.3. Helen Glaves, BGS, UK, Ocean Data Interoperability Platform (ODIP) – Developing a common framework for marine data management on a global scale

The Ocean Data Interoperability Platform, an EU-USA-Australia collaborative project, includes regional marine data infrastructures brought together by EU, Australia, and USA, There are currently two phases: ODIP I, which is completed and ODIP II, which started earlier this year. ODIP I was funded in parallel by European Commission, National Science Foundation (NSF) and Australian Government but funding for ODIP II is less clear for both the USA and Australia due to a change in priorities for the relevant agencies in these regions. The ODIP objectives include: the development of a common approach to marine data management that can be extended to other regions and organizations; the establishment of a co-ordination platform to support development of interoperability between existing marine data management infrastructures; the creation of prototype interoperability solutions to demonstrate this coordinated approach. ODIP holds regular joint workshops to develop interoperability solutions and/or agree on common standards; this is supplemented by creating and publishing inventories of existing standards and policies and developing prototypes for testing and evaluating potential interoperability solutions. ODIP has 3 prototypes (ODIP1, 2 and 3). ODIP1 is establishing interoperability between the SeaDataNet, the Australian Ocean Data Network (AODN) and the US NODC data discovery and access services, initially focused on metadata discovery services using GEO-DAB brokering services. It is led by European partners via SeaDataNet. In ODIP2, interoperability was established between SeaDataNet/ US NODC/AODN metadata discovery services and IODE-ODP and GEOSS portal. The ODIP2 prototype was led by Rolling Deck to Repository (R2R) partners (USA). In ODIP3, the aim was to identify and adopt common SWE standards for Sensor Observation Services (SOS) but due to the lack of maturity of these standards in the participating regions this has not been achieved. Instead a community of practice has been created to take this objective forward in the ODIP II project. This activity is led by AODN/IMOS(Australia).

ODIP II: Extending the Ocean Data Interoperability Platform, is a 36-month project that started in April 2015. As a continuation of ODIP I, this new collaborative project includes Europe, USA, Australia and related international initiatives: IODE, POGO. ODIP II expands the scope of ODIP to cover other domains e.g. marine biology, and to include additional partners. ODIPII objectives include: developing common approaches for specific aspects of marine data management e.g. vocabularies, formats, sensor web enablement, etc. There will be further development of existing and new prototype interoperability solutions building relationships with other regional data infrastructures.

6.4. Benoit Pirenne, Oceans Network Canada, An OCN Update

Ocean Networks Canada (ONC) is the home of the North East Pacific VENUS (coastal), NEPTUNE (offshore), and Cambridge Bay (Arctic) cabled observatories, with a total of over 200 instruments, and hundreds of science sensors. The observatories typically have the following capabilities: up to gigabits of bandwidth (4Gbps/node); typically kilowatts of available power (8 kW @ 400V per node); precision timing (NTP, PTP protocols supported); capacity for hundreds of attached devices with over 50TB/year data flow. Services are available up to 3000m water depths.

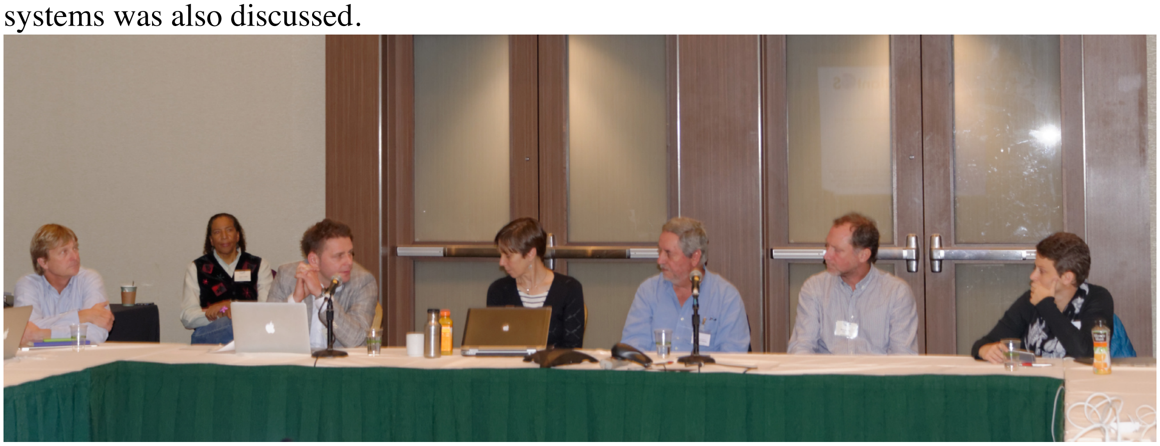
So far ONC includes over 85 different types of instruments (the total is currently over 220 instruments with over 850 sensors (with many more planned). ONC's *Oceans 2.0* data management system includes a variety of tools to monitor and control the observatories, including a full suite of metadata management features.

The magnitude of the volume of data versus the number of people who can analyze the data presents a challenge. Through continuous improvements to it's *Oceans 2.0* data management system, ONC is exploring methods to address the widening gap: tools such as Data Preview with specialized capabilities for specialized data sets (e.g., acoustic data, video); interactive (web interface) and computer-to-computer tools (web services) for data download. Additional analysis capabilities are envisioned through the participation of citizen scientists. Benoit gave some examples of the data preview for the strait of Georgia, and the citizen science application on ships of opportunity. Looking forward, ONC is building Smart Ocean Systems™ a concept where observations in the field allow to continuously monitor, detect, and respond to natural and man-made events and directly addressing society needs.

Data Panel - from left - Helen Glaves, Dick Schaap, Oscar Schofield and Benoit Pirenne

6.5. Cindy Chandler, WHOI, Summary of presentations, and Question/Answer session
Cyndy Chandler coordinated the questions and discussion on data and Information systems. Quality control was mentioned by all of the large programs. This can be automated in many ways. How much effort is spent on data quality control? Dick Schaap said that he has no numbers but there are people assigned to do this at his data center. For climate change, there is a higher criterion for quality. But for many purposes, there is less quality required. And some data, like bathymetry in the Black Sea, may require a lot of effort to remove the sound speed variations. Benoit said there are lots of people looking at the data coming in from Neptune. Operators look at the metadata. It's can be a boring job but is absolutely necessary. Sometimes artifacts are found that make it less boring. Comparison to a standard is hard but necessary and, in some cases, requires working with a sensor manufacturer. It is also necessary to involve the users. For example, 350 profiles a day are taken in one program but 10 or so are not good. Fifty profiles a day are the responsibility of each operator. NASA has huge data sets and the responsibility to check the quality of the data. The priority is to produce data sets that are trustworthy. The repositories acknowledge that there will be items in the data flow that are not right and encourage suggestions for corrections and improvements. Data quality needs to be addressed further.

7. Francisco Chavez, MBARI, Panel on Ocean Biology – from microbes to whales
Biology has lagged physics and chemistry in terms of autonomous observing sensors and systems but significant progress has been made recently. Francisco Chavez organized this session to address progress in autonomous observing of life in the sea. Following the theme of the session it started with progress in microbial oceanography and worked its way to top predators. The role of biological observations within AtlantOS, the US IOOS and global GOOS systems was also discussed.



Biology Panel - from left - Chris Scholin, Maciej Telszziewski, Heidi Sosik, Francisco Chavez, Eric Delory, Samantha Simmons

7.1. Chris Scholin presenting for Elisha Wood Charlson, University of Hawaii, 'Omics Observations (ECOGEO)
Chris Scholin talked about ecogenomics and the progress and potential for genetic monitoring of marine organisms. This is a relatively new field that is creating a lot of interest. His first presentation was developed by Ed Delong and Elisha Wood-Charlson about the ECOGEO EarthCube RCN, dealing with the 'omics issue. 'Omics can defined as a suite of tools to help us describe marine diversity. It starts with single cell genome, multiple cell - metagenome, active

genes - transcriptome and finally functional proteins - proteome. The microbes are at the base of the food web. 'Omics is the only way to decode their diversity and functional activities in Earth system processes. Most of the oceanography communities at large are using the same data. This ECOGEO RCN represents many independent projects, but also the community's need for cyber-infrastructure development, such as Simons Collaboration on Ocean Processes and Ecology (SCOPE) [http://scope.soest.hawaii.edu], and data from ocean observing systems. SCOPE brings together domain scientists and modelers using -omics. Accessing what the organisms are telling us is a rich source of information regarding ocean change. A key consideration in that regard is sampling microbial communities with respect to relevant time/space scales – something that is challenging to do using manned ships only. With that in mind, MBARI has developed the Environmental Sample Processor (ESP) to automate sample and oceanographic data collection, and for some applications to fully automate use of molecular probe assays for detecting DNA, RNA, or metabolites indicative of specific organisms.

7.2. Chris Scholin, MBARI, Platforms and Sensors for Enabling Marine Microbial 'Omics Observations

Chris Scholin gave a second presentation about platforms and sensors for enabling –'omics observations. As noted earlier, a fundamental challenge of is collecting material. Ed DeLong has made a space-time sampling scatter to better understand the attributes and challenges of collecting samples at different scales. Chris noted that the relevant time domain for microbes runs from hours to days. Considering both the time and spatial domains, we have terribly under-sampled, as there are large variations in both that tie across the mesoscale horizontal distances, at a given depth. "Taking the Pulse of the Ocean" (supplied by the University of Washington at Seattle) is a graphic that captures a concept for sampling microbes and applying molecular analytical approaches for analyzing those samples in the context of a large-scale ocean observing system.

A sensor is needed for enabling 'omics research. It requires sample acquisition, sample handling, target acquisition and analyte detection. Looking at lessons learned so far, the ecogenomic sensor concept is valid; a sample preservation capability for subsequent analyses of, for example, DNA has been shown to complement real-time analyses. Creating data presentations that intuitively link microbial activity to space, time, and environmental fluctuations remain a challenge and is a priority for the near term. Any snapshot of microbiology is a record of the past, so accurate interpretation of microbial community activity with respect to prevailing environmental conditions requires space/time understanding of recent events that have given rise to the current condition. With that in mind, the MBARI team is designing a small fleet of new ESPs fitted to long-range AUVs that will have a range of 300m in depth and several hundred km of horizontal movement in the open sea. The goal is for a cohort of "mobile ecogenomic sensors" to capture an integrated (and possibly dynamic) view of the ocean environment and the resulting microbial community. A concept graphic showing several of these AUVs moving around and through an internal wave with chlorophyll on a density interface shows the need and challenge of sampling such a dynamic process..

Makai is a mobile ecogenomic sensor prototype; it is the merger of MBARI's third generation (3G) ESP and long-range AUV (LRAUV). The 3G ESP uses a cartridge-based system for sample collection and processing. By defining common cartridge interface standards, it is possible "open source" cartridge development to gain new sample processing and analytical capabilities using a common "front-end" collection system. For example, DNA extracted from samples can be processed in several ways. One example shown illustrates use of such DNA for high throughout sequencing (commonly used for microbial community diversity assessments) as well as targeted gene detection. In addition to collection of microbes, the 3G ESP has been shown capable of collecting "environmental DNA" – material shed into the water by larger animals. This capability was first demonstrated July 2015 using Makai to collect samples that later were determined to harbor DNA indicative of anchovies. Several of these 3G ESP/LRAUVs are being built for collaborators Ed DeLong and Dave Karl at the University of Hawaii, Manoa, and will be used in support of the SCOPE program (etc.).

Questions/discussion

Marine Biodiversity Observation Networks are an evolving global initiative with nodes in the Pacific off the west coast of North America. Life in the sea is responding to environmental forcing at a variety of spatial and temporal scales. The use of these assets to sample life in the sea thus needs to be done adaptively.

Questions/discussion

Biodiversity observation network is a concept in the Pacific off the west coast of North America. The environment is forcing the activity of these assets and thus needs to be done adaptively.

7.3. Heidi Sosik, WHOI, Ocean Observing for Plankton: Needs and Methods

Following Chris Scholin's discussion of 'omics, Heidi Sosik presentation focused on organisms instead of genes. There is a need for organism level sampling as there are functionalities that are mediated by the organism's morphology. The observations need to cover the range from hours to seasons, and need spatial scales from microns to meters. In some cases, even minutes to decades for observations are required. This leads to multiple instrument designs. Flow cytometry is a powerful tool. It is automated in the ocean and also has imaging in flow. FlowCytobot evolved to Imaging FlowCytobot, which also images the organism. They have been deploying FlowCytobot and Imaging FlowCytobot side-by-side at Martha's Vinyard Coastal Observatory (MVCO) [http://www.whoi.edu/mvco/]. This mode allows observation of the entire phytoplankton community from pico-plankton through micro-plankton . The technology also provided early warning about toxin producing organisms in Port Aransas, Texas. A challenge for long-term operations is biofouling control where optical surface and fluidic systems as well as intake must be protected. Microbeads can be used to monitor performance over time. Size, power and bandwidth/storage are always on the minds of the team. Staining can enhance the detection of protozoan taxa. Imaging approaches are powerful and can be implemented in a variety deployment modes. For example, the Jupiter Research Foundation has recently demonstrated phytoplankton imaging from a Wave Glider. For larger size plankton, recent advances include the Continuous Particle Imaging and Classification System (CPICS). For the analyses discussed involving the MVCO time series, sorting through several hundred million images was needed. Only a small percentage of these can be manually verified so automated processing and machine learning approaches are critical. Thus, there is a pressing need for information management.

Questions and discussion

How much of the analyses are manual versus automated? They looked at 3 million out of 700 million images over a period of years; every 2 weeks they selected and annotated a set of images, ultimately gearing up for new classifier. Information management is a big challenge but Heidi believes the need can be met. Fisheries scientists are intensely interested in knowing fundamental data in building models for productivity from the bottom of the food chain. There is a long list of society relevant issues for monitoring life in the sea and progress is being made.

7.4. Francisco Chavez, MBARI, MBON Demonstrating Marine Biodiversity Observation Networks – from microbes to whales

Francisco Chavez said that the microbial scientists have led the way in the development of autonomous tools to observe and understand life in the sea. The Marine Biodiversity Observing Networks (MBON) are an evolving effort funded recently by NASA, NOAA and BOEM. They link to the Group on Earth Observation (GEO) through GEO BON, whose focus to date has been mostly terrestrial. Blue Planet is a GEO ocean initiative and is charged with coordinating the ocean activity in GEO. The MBON vision is that marine life is the engine of ocean ecosystems that support us. Huge investments have gone into ocean observing system, but no systematic effort has gone into observing life in the sea. US MBON and Tennenbaum [http://newsdesk.si.edu/releases/smithsonian-launches-global-marine-biodiversity-project-10-million-donation] are the first systematic efforts to understand marine life, how it is changing and how that affects us.

MBON is a regional collaboration that integrates, synthesizes and augments biodiversity information from ongoing programs; it develops and uses advanced methods (acoustics, fluidics, genomics, video/optics) for conducting biodiversity assessments. To do this effectively, MBON brings biodiversity and environmental data together and serves it using national and international standards. In addition, it develops and then uses advanced analysis and modeling tools to determine what drives the mean and fluctuating components of biodiversity and ecosystem function. Ultimately, MBON relates information to social-economic context and provides information rapidly to stakeholders, seeking to do this as an operational system.

In late 2013, National Ocean Partnership Program (NOPP) issued a call for proposals in support of demonstration Marine Biodiversity Observation Networks (MBON). Three proposals were selected, one in the Santa Barbara Channel, a second in the Arctic/Alaska region and a third in the Florida Keys and Monterey Bay National Marine Sanctuaries. NASA and NOAA (IOOS, SWFSC) were sponsors for the 5-year projects with total support of about $17M (BOEM and Shell funds for Arctic). Smithsonian Tennenbaum BON was drafted to be part of the team. The focus of the talk was mostly on technological developments required to make these MBON sustainable.. For example, automatic image analysis of video is needed. Also, it is critical to be smart to select where and when samples are collected in order to get scalable results while controlling cost. Environmental DNA (eDNA), the sloughing of material from living organisms and collected in a water sample, can be potentially used to identify everything from microbes to whales. Experiments where eDNA (‘omics) water samples were collected by divers at the same time as fish were counted have demonstrated that eDNA is a feasible technique. The MBON effort is only just beginning but has attracted global attention with many interested parties willing to join. An important next step is the development of best practices for data collection, sample processing, data management, visualization and product generation, and user engagement.

7.5. Samantha (Sam) Simmons, Marine Mammal Commission, the Biology & Ecosystems Panel of GOOS: integrating biology and ecosystem monitoring

Samantha Simmons first talked about informing Priorities for Biological and Ecosystem Observations, supporting evolution of the U.S. Integrated Ocean Observing System (IOOS). US IOOS had 26 core variables, 21 physical and chemical and 5 biological. The biological are phytoplankton, zooplankton species, zooplankton abundance, fish species, and fish abundance. Ocean Obs'09 provided the framework for ocean observing: characterizing observing systems across disciplines & technologies, establishing priorities for observing, and identifying readiness level. One of the team goals of the BIO-TT was to identify and prioritize crosscutting biological and ecosystems needs. A survey of needs was conducted. The survey started with 60 biological variables that were reduced to 36 during a BIO-TT workshop. Each variable was assessed based on impact (on ocean environment/ecosystem management) and feasibility for observations. Each variable was then rated based on 5 themes: productivity, biodiversity, ecosystem services, human activities & pressures, and feasibility. Preliminary recommendations follow. Highest priority should be to include **species and abundance** of other core functional groups (pelagic and benthic) that are not in the current core variables list. Following species and abundance, **biological vital rates (BVRs)** are the next priority of biological information to be included as IOOS core variables. BVRs include, production, recruitment, mortality, fecundity, growth, and feeding rates; also, information on **nekton diet** should be included as an IOOS core variable. Finally **sound** should be included as an IOOS core variable. By measuring sound in the ocean a great deal can be discovered about the environment.

Samantha then addressed the Biology & Ecosystems Panel of GOOS, whose objective is integrating biology and ecosystem monitoring. From a BIO/ECO perspective, the goals are to develop and coordinate efforts in the implementation of a sustained and targeted global ocean observation system driven by societal needs to include EOVs; and to answer relevant scientific and societal questions, and facilitate policy and management development on ocean and coastal resource sustainability and health. GOOS focuses on measuring what is most important including Essential Ocean Variables. We need variables that can tell us about the changes in ecosystems. The DPSIR model is used where the model addresses the following factors: D - the societal questions, sectoral trends, national and international obligations that *Drive* the need to monitor marine biodiversity and ecosystem health; P - the human *Pressures* affecting the environment that are or will impact marine biodiversity and ecosystem health; S - the existing initiatives that could be built on to measure the *State* of the marine environment? I - the priority *Impacts* on the marine environment that need to be monitored, how well do existing initiatives address those needs and what are the key gaps; R – identify monitoring information that is most likely to be used to help society *Respond* to identified impacts. Thus, drivers and pressures on the state of the marine environment and their probable impacts must be defined and decisions need to be identified that can address the impact. There are 9 drivers and 10 pressures. A survey was used to assess the state of ocean observing programs. For GOOS Bio Eco, the tasks ahead are to be addressed by 2019 (date of next Ocean Obs). This includes the objective to implement and mature an observation program of at least one (set of) EOVs providing an indicator of change, globally coordinated aimed for global coverage, open access data, and to support international reporting needs. Identify a further 3 (sets of) pilot EOVs with a clear pathway to progress to mature programs.

A model of community meetings and/or a town hall to get input from the community is needed. As a next step, a face-to-face meeting is to take place at the Ocean Science meeting in February 2016.

7.6. Eric Delory, PLOCAN, AtlantOS

Eric Delory from PLOCAN spoke about AtlantOS and its Work Package 6: Crosscutting issues and emerging networks. He is sharing the leadership of the work package with Jay Pearlman and Matt Mowlem. The focus is new technologies including a link to biodiversity. The purpose is enhancing and optimizing the integrated Atlantic Ocean Observing System. There are a lot of observations but they have no network. AtlantOS is a 20MEuro European H2020 project which is a child of GEO and GOOS; it will operate as an integrative part of them. AtlantOS opportunities include: improving international collaboration in the design, implementation and benefit sharing of ocean observing; promoting engagement and innovation in all aspects of ocean observing; free and open access to ocean data and information; quality and authority of ocean information. It will deliver against the Galway Statement with expansion to include the South Atlantic. Marine biodiversity monitoring systems includes megafauna - Ocean tracking network, passive acoustics (NeXOS), plankton sampling/monitoring from fixed open-ocean and mobile stations, fisheries – RECOPESCA+ (NEXOS), link with GBIF, GEOBON, OBIS, EMBOS, BISE, WoRMS. It will also link with EU Lifewatch, EOOS, EMODNET. SSCO 2014 in Brest showcased new sensor technologies, lower costs and improved sustainability. In addition to the observation networks, there are cooperation opportunities for the Global and Ocean Class research fleet through the Ocean Exchange Facilities Group (OFEG), which provides a forum to barter opportunities for the research fleet.. There are also opportunities for scientists including provision for international funded research time, including mobility (e.g. Global EU Marie-Curie Fellowships, Canada).

Eric Delory then briefly discussed the NeXOS project, developing new schemes based on new technologies – NeXOS sensors being developed include Multiplatform multifunctional optical sensors for Green House Gases and Contaminants; multiplatform multifunctional ocean passive acoustic sensors for Noise and Bioacoustics; new robust and low-cost sensors for fisheries management; scientific, technical and market requirements to be refined and further studied during the project life time; multiplatform validation and demonstration..

7.7. Francesco Chavez, MBARI, panel discussion

A panel discussion, on Ocean Biology – "from Microbes to Whales" was led by Francisco Chavez. Real integration within GOOS is forthcoming. At OceanObs 2009 there was a call to embrace a framework for planning and moving forward with an enhanced global sustained ocean observing system over the next decade, integrating new physical, biogeochemical, biological observations while sustaining present observations. Climate, weather, ocean physics and services have led the way in terms of ocean observations. Biochemistry was next to follow as a result of available sensors for oxygen, nitrate and now pH. Biology is now ready to follow suit. A question that now emerges is how to integrate climate, ocean physics, biogeochemistry and biological observations to create the products needed by society? Without some form of information synthesis, society won't be able to use the data wisely. With the emerging opportunity to define EOVs from the scientific side across ocean disciplines, there are questions of how to guide the growth in capability. If we are going to bring together observations and information from climate, ocean physics, biogeochemistry, and biology (the complete ecosystem), do we start with what is needed from a science perspective or from the perspective of what we can measure from an operational capacity? How do we integrate user needs? In considering this, Eric Lindstrom noted that there are “Dimensions of Integration” and suggested that considerations range across: international; national; regional; science discipline; “EOV”; network; platform; product; and requirements. Ultimately, we have to combine everything with a system view. Much in the same way as an ecosystem is defined as a community of living organisms (including humans) in conjunction with the nonliving components of their environment as a system. With AtlantOS, priority in integration is through use cases. MBON is a good use case; select one of 2 use cases as way to move forward.

8. Ari Asmi, University of Helsinki, ENVRIplus – Coordination of Diverse Research Infrastructures

Ari Asmi of the University of Helsinki gave a presentation about the European project, ENVRIplus [http://www.envriplus.eu]. Interlinked systems involve atmosphere and lithosphere, biosphere and hydrosphere and holistic understanding allows these to provide for society. The key strategic directions of ENVRIplus are to support primary customers who are the twenty-two Research Infrastructures (RIs) where all project products must be open to all and useful to two or more RIs. The RIs take part directly in the development via participation in the work packages (customer driven, co-design approach). ENVRIplus is a growth from previous projects including the initial ENVRI project and COOPEUS, a multi-domain project with Marine Applications as a major element. COOPEUS also extended the collaboration with a EU/US interface. ENVRIplus has a number of European marine infrastructures and research organizations including, for example, EuroGOOS, Marine Biological Association of the UK, IFREMER, PLOCAN, EuroARGO, NERC and EMSO

ENVRIplus is organized in 6 themes: 1) technical innovations – focus on observing systems, common new sensors, extreme environments; 2) data for science – reference model development, ontological framework, implementation plan, data identification, curation and semantic annotations, catalogue interoperability, and data provenance; 3) access to RI - guidelines on access to RIs, RI strategy, paths of physical access to RIs, access to RIs across disciplines, governance tools; 4) societal relevance and understanding - link earth observation data to human systems, develop reference model to understand data impact, feedback system, ethical aspects, ethical reference framework, social role, ethical and social aspects, citizen science test cases; 5) knowledge transfer - teaching RI operators key skills, time series analysis, management training, RI products use, secondary school, sharing symposia consulting groups; and 6) communication and dissemination - cluster level integration, sustainability, ENVRIplus dissemination, promotional, economics, and consulting groups. In summary, ENVRIplus is a project for the research infrastructures, stressing co-Design approach, open products, and open collaboration.

9. Mairi Best, Consultant, Citizen science, what can it do for science research?

Is citizen science a nice thing to do or are there cases when you cannot reach your objectives any other way? Three example areas were examined that touch on this.

The first looks at image annotations done by citizens. The human brain is best to do that. A common tool is being developed through ENVRIplus (see previous section) in the context of two subsea observatories (EMSO and ONC) to help develop citizen supported image analysis. Citizens provide annotations. These can lead to answering scientific questions such as**: "**How does crabs' (or shrimp or whelks) spatial distribution evolve over the years?" or "How do fish populations evolve over time?". Another approach to image annotation includes gamification, for example, the Digital Fishers at ONC provides video footage in a game format; to date, 3000 participants have been involved, looking at 140,000 pictures.
The second area addresses community-based science. Examples include Smart Oceans BC, First Nations and Inuit engagement, School programs, and Community Fishers and Reef surveys by volunteer divers.
A third area is sensor deployment by volunteers. For example Quakecatcher is a USB low-cost sensor that can turn a laptop or PC into a seismic station; Kduino is a student-assembled aquatic light detector to monitor environmental changes in the upper water column in both marine and fresh water settings.
So citizen science can give you greater spatial coverage, remote locations, temporal coverage, event response, instrument manufacture and maintenance, instrument deployment/sample collection, data collection and transmission, data analysis.
In conclusion, there is a need for tools and resources to effectively engage, train, and maintain Citizen Scientists: data systems for acquisition, assessment, access, and analysis of distributed data sources; community on-line Platforms (websites, social networks, discussion forums); crowdsourcing tools (image acquisition, web and smart-phone applications, surveys/questionnaires); information and training resources (webinars, public lectures, websites, public/museum displays); and citizen mobilization (rapid response observations to events (e.g. earthquakes, oil spills), opportunity for engagement).
Questions/Discussions
Other examples of citizen involvements include "fold it" at UW; one on microbes (UK); use of sensors in private yachts; ocean sampling; and humans as sensors.
Who are citizen scientists vs. other stakeholders? Good point that involvement in science includes a continuum of expertise, and can include for example ship operators.

10. Jay Pearlman, brief summary of meeting
Jay provided a summary of today's RCN discussions, recognizing successes and challenges. Heidi and Chris reported successes regarding advances in living organisms. The XPRIZE for pH sensors provided innovative solutions for accuracy and sustainability. Regarding challenges, we need to address how to manage data, especially big data, and make recommendations. We need to work together and observatories do not always collaborate. Essential ocean variables that are needed in another discipline should be shared including announcements of cruise opportunities so other measurements can be coordinated. The Schmidt cruise is an example of where we can collaborate.

2015 RCN Face-to-Face Meeting Attendees

Allen	Simon	Spatial analytic
Asmi	Ari	University of Helsinki
Bender	Sara	Moore Foundation
Best	Mairi	EMSO
Chandler	Cyndy	WHOI
Chavez	Francisco	MBARI
Chiba	Sanae	JAMSTEC
Delory	Eric	PLOCAN
Glaves	Helen	BGS
Goldstein	Philip	OBIS-USA
Gough	Ed	IEEE OES
Holthus	Paul	WOC
Houtman	Bob	NSF
Lindstrom	Eric	NASA
O'Reilly	Tom	Mbari
Orcutt	John	UCSD
Pearlman	Francoise	IEEE
Pearlman	Jay	IEEE
Pirenne	Benoit	ONC
Plag	Hans-Peter	Old Dominion
Schaap	Dick	SeaDataNet
Scholin	Chris	MBARI
Simmons	Samantha	MMC
Sosik	Heidi	WHOI
Telszewski	Maciej	Polish Institute
Virmani	Jyotika	X Prize
Williams	Sandy	WHOI
Wright	Dawn	Esri
Zykov	Victor	Schmidt Institute